ONTARIO

ENRICHMENT STATUS
of
THIRTEEN LAKES
Haliburton Highlands Region

1973

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by

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SUMMARY

In general, the biological quality of thirteen lakes in the Haliburton Highlands area as evinced from Secchi disc - chlorophyll readings secured during the summer of 1972 was excellent. Some concern is expressed relative to troublesome levels of algae occasionally reported from Canning, Kashagawigamog and Moore's Lakes. The extreme vulnerability of Little Glamor Lake to small continued inputs of nutrients - particularly phosphorus - was indicated. For Big and Little Glamor Lakes - the only lakes where two consecutive years of data are available, higher algal densities and lower light conditions occurred in 1972 than in 1971. In light of the aforementioned, a continuation of the Secchi disc - chlorophyll study in the thirteen lakes should be carried out. Preferably, data collections should be accomplished on a weekly basis during the ice-free period of the year.

Cottagers should be aware that unless artificial nutrients are kept from gaining access to the lakes, future water quality will most certainly be undermined. In this connection, every effort should be made to ensure that nutrients from sink and laundry wastes, including automatic dishwashers, as well as seepage from septic tank systems and garden fertilizers do not gain access to the lakes.

INTRODUCTION

Over the past few years an increasing awareness and concern for problems of pollution in recreational lakes has materialized as a consequence of accelerated cottage development. Many individual cottagers, cottage associations' and permanent shoreline residents have requested that complete water quality evaluations be carried out to assess the degree of pollution in lakes. Exhaustive physical, chemical, bacteriological and biological evaluations for a large number of lakes are beyond the financial and logistical capabilities of personnel involved in water management programmes, and in light of recent studies, are not necessary in order to categorize the quality of recreational waters. An understanding of water quality problems in recreational lakes is provided in Appendix 'A'.

In 1971, a practical but effective evaluation programme was carried out on seventeen recreational lakes in the Province of Ontario. The programme, which involved the collection of data on water clarity and algal populations, was highly successful owing to the enthusiastic efforts of local residents, cottagers, marina and resort owners, and personnel of the Ministries of Natural Resources and Environment. The success of the programme was exemplified by the fact that in 1972 the number of lakes sampled increased from seventeen to fifty-eight. This preliminary report presents the Secchi disc - chlorophyll information from thirteen lakes in the Haliburton Highlands region of Ontario during the summer of 1972, incorporates the data into a mathematical relationship for the parameters measured and comments on the findings with a view to defining the current state of enrichment or trophic status of the lakes.

METHODS

Water clarity which governs the depth of light penetration in a lake is one of the most important parameters used in defining water quality and can be measured using a Secchi disc. The disc is divided into black and white alternating quadrants and is lowered into the water on a graduated line until the quadrants cannot be distinguished. The depth at which the disc just diappears is termed the Secchi disc depth. As depicted in Figure 1, Secchi disc depths are substantially greater in lakes having low phytoplankton (microscopic free-floating algae) numbers than in lakes characterized by high algal densities and excessive vascular aquatic plant growths. Secchi disc readings were taken as often as possible during the summer of 1972 in the deep-water zones of thirteen lakes of the Haliburton Highlands region. Usually, two readings per visit were obtained; a mean of the two readings was recorded as the Secchi disc depth.

Chlorophyll a is the amount of phytosynthetic green pigment in algae and its concentrations can be used as a rough indication of the extent of biological activity in a lake at the time of sampling since it is regulated by all of the combined physical, chemical and biological factors which affect algal production. Chlorophyll samples were taken on each visit to the lakes by lowering a 32-ounce bottle provided with a restricted opening to the approximate location of the 1% incident light level or zone of effective algal production. This zone was determined as twice the Secchi disc depth. The samples were immediately preserved with 10-15 drops of a 2% magnesium carbonate solution and delivered to the Ministry of Environment's mobile laboratory located on the campus of Trent University in Peterborough. Following filtration using 1.2μ Millipore filters and cooling, the samples were transported to Toronto for analyses.

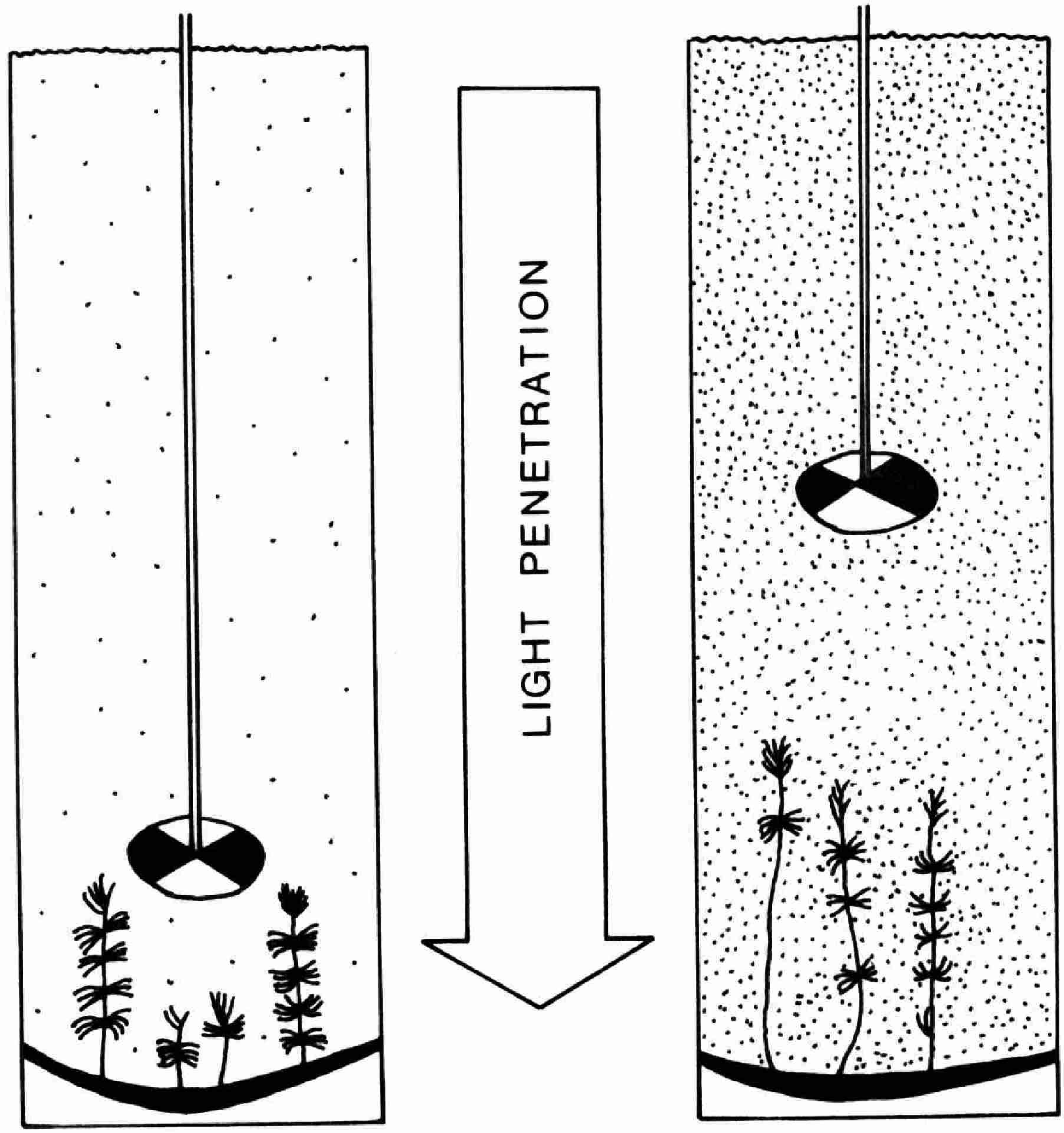

Figure 1: Diagram illustrating the use of a Secchi disc to measure water clarity. Greater visibility characterizes clear lakes having low algal densities (left panel) than productive lakes which contain high algal levels and have low light penetration (right panel).

DISCUSSION OF RESULTS

The chlorophyll a concentrations and Secchi disc values collected from the thirteen lakes are presented in Table 1. Secchi disc readings were lowest in Little Glamor Lake: the most transparent lakes in the study area were Big Hawk and Hall's Lakes and Stations B and C of Kenissis Lake. Recent evidence from in-depth studies carried out in Lakes Joseph, Rosseau and Muskoka in the Muskoka Lakes area of the Province suggests that lakes having Secchi disc readings less than 9.6 feet are eutrophic or enriched in nature while exceeding 16 feet are oligotrophic or unenriched in status. Lakes having Secchi disc recordings between 9.6 and 16 feet would be mesotrophic or moderately productive, that is, they have a moderate supply of nutrients, plant growths and biological production. On the basis of these guidelines alone, six lakes (Big Hawk, Boshkung, Shadow, Hall's, Twelve Mile and Stations A,B and C of Kenissis Lake) would be oligotrophic, six lakes (Big Glamor, Canning, Davis, Kashagawigamog, Moore's and Station COA of Kenissis Lake) would be mesotrophic while Little Glamor and Stormy Lake would be decidedly eutrophic.

For the most part, chlorophyll a concentrations were low; however, relatively high levels of 16, 15 and 17 parts per billion (ppb) were recorded in Canning, Kashagawigamog and Moore's Lakes on September 10, August 5 and September 11, respectively. Experience has indicated that concentrations between 0 and 3 ppb are low and indicate low to moderate algal densities. Concentrations between 3 and 6 ppb although moderately high may be considered acceptable for most water oriented recreational pursuits. Levels exceeding 6 ppb on a yearly average, reflect high algal densities. At these higher levels deterioration of water quality for recreational activities such as swimming and water skiing may be expected as well as a reduction in aesthetic quality. As indicated in Table 1, chlorophyll levels in the selected lakes were generally low reflecting good water quality conditions. Concern is expressed relative to the occasional high values recorded for Canning, Kashagawigamog and Moore's Lake during the late summer.

TABLE 1: Secchi disc (feet) and chlorophyll data (parts per billion) collected from thirteen lakes in the Haliburton Highlands region, during the summer of 1972.

LAKE	Date	Secchi disc (feet)	Chlorophyll a (parts per billion)
Big Glamor	3/7	11	3.0
	23/7	12	2.9
	30/7	10	4.7
	13/8	15	3.0
	Mean	12.0	3.4
Big Hawk	24/7	18	1.0
	30/7	19	0.6
	7/8	18	0.6
	13/8	19	1.0
	20/8	27	1.0
	27/8	23	1.0
	Mean	20.6	0.8
Boshkung	9/7	16	1.2
	30/7	20	1.1
	6/8	16	1.0
	13/8	20	1.7
	20/8	19	1.0
	3/9	20	1.0
	Mean	18.5	0.9
Canning	2/7	16	1.5
	9/7	13	2.1
	23/7	12	1.9
	30/7	15	2.4
	13/8	16	2.0
	20/8	19	1.7
	27/8	17	1.7
	4/9	14	1.4
	10/9	18	16.0
	17/9	15	2.3
	24/9	14	1.0
	Mean	15.3	3.0

Table 1 - Cont'd....

LAKE	Date	Secchi disc (feet)	Chlorophyll a (Parts per billion
Davis	25/7	12	2.9
	30/7	15	2.6
	6/8	15	2.4
	13/8	14	1.5
	21/8	15	1.4
	27/8	17	1.7
	4/9	20	1.1
	Mean	15.3	1.9
Hall's	9/6	26	0.3
	2/7	27	0.6
	23/7	25	1.0
	30/7	30	0.7
	6/8	32	0.7
	13/8	31	1.0
	20/8	27	1.0
	27/8	31	1.0
	Mean	28.5	0.7
Kashagawigamog	2/7	10	3.4
	9/7	12	2.8
	23/7	13	2.5
	30/7	15	5.1
	5/8	17	15.0
	13/8	12	5.6
	20/8	12	2.2
	3/9	12	1.1
	Mean	14.0	4.7
Kenissis - Station A	9/7	15	0.7
	23/7	29	1.0
	30/7	20	1.2
	6/8	11.5	1.1
	12/8	30	1.0
	19/8	28	1.0
	Mean	22.2	1.0

LAKE	Date	Secchi Disc (feet)	Chlorophyll a (parts per billion)
Kenissis - Station B	9/7	32	0.6
	29/7	26	0.9
	4/8	34	0.7
	12/8	20	1.1
	20/8	38	1.0
	Mean	30.0	0.9
Kenissis - Station C	9/7	30	0.6
	23/7	27	1.0
	29/7	30	1.1
	4/8	30	0.7
	12/8	32	1.0
	20/8	28	1.0
	Mean	29.5	0.9
Kenissis - Station COA (Little Kenissis Lake)	23/7	10	1.1
	30/7	11	3.7
	6/8	23	1.0
	12/8	13	0.9
	19/8	16	1.2
	Mean	14.6	1.6
Little Glamor	3/7	7	4.4
	9/7	5	3.1
	7/8	5	9.3
	18/8	6	5.5
	23/8	6	3.9
	27/8	7	5.0
	Mean	6.0	5.2

Table 1 - Cont'd....

LAKE	Date	Secchi Disc (feet)	Chlorophyll a (parts per billion)
Moore's	2/7	15	1.3
	8/7	15	1.1
	23/7	14	1.6
	12/8	17	3.5
	28/8	16	3.1
	11/9	10	17.0
	Mean	14.5	4.6
Shadow	2/7	16	1.0
	9/7	18	1.0
	23/7	18	1.5
	6/8	20	0.8
	20/8	38	1.1
	27/8	19	1.0
	Mean	20.0	1.0
Stormy	25/6	8	1.7
	23/7	8	3.9
	13/8	8	1.3
	20/8	10	1.9
	4/9	12	1.4
	17/9	9	1.6
	Mean	9.3	1.9
Twelve Mile	25/6	19	1.0
	2/7	17	0.6
	9/7	19	1.0
	23/7	18	1.0
	30/7	20	1.8
	7/8	19	1.5
	13/8	21	1.1
	27/8	19	1.6
	4/9	22	1.5
	Mean	19.3	1.2

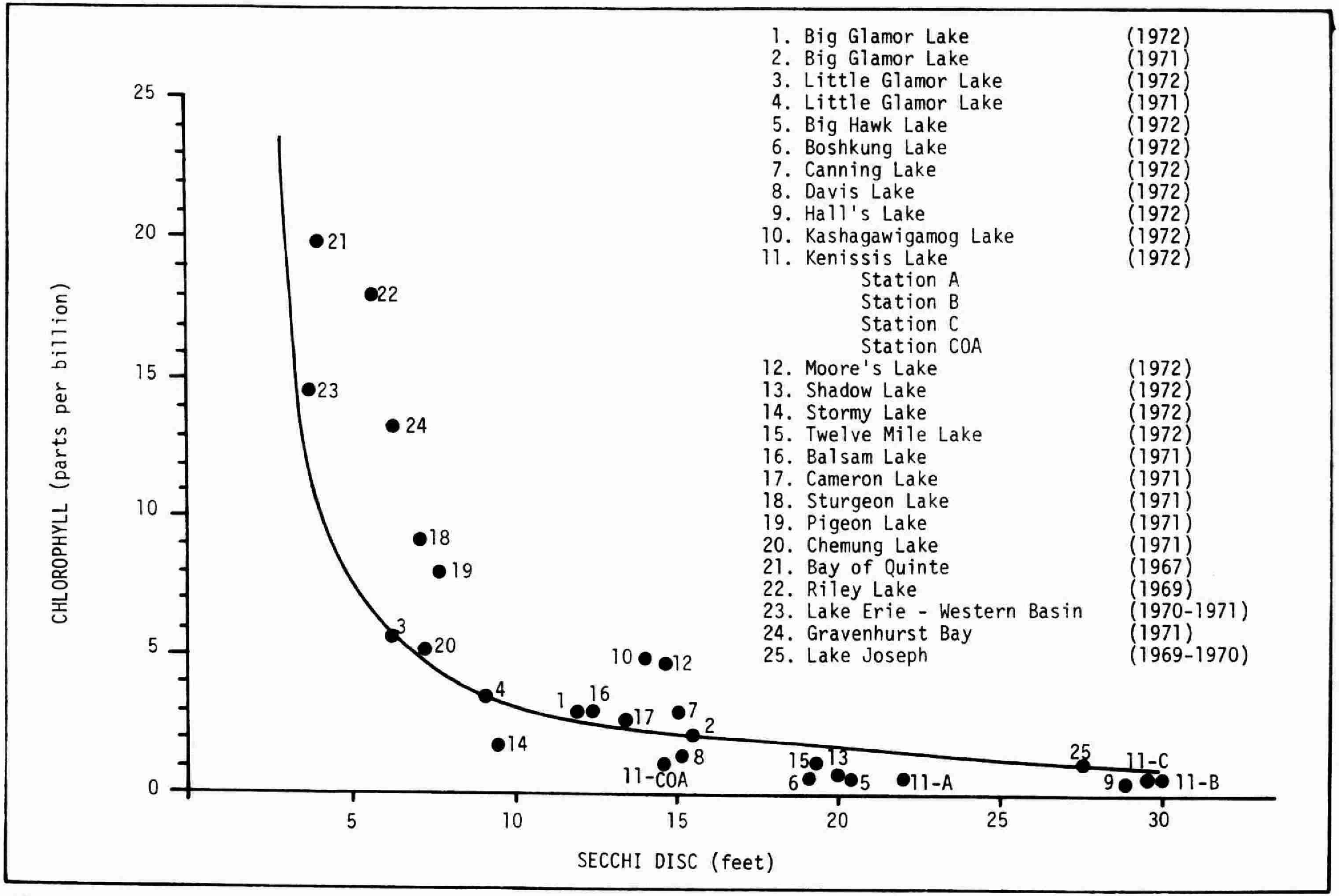

Figure 2: The relationship between chlorophyll a and Secchi disc for thirteen selected lakes in the Haliburton Highlands region of Ontario. Values for each lake are based on mean values collected during the summer of 1972. Also, information from a number of other lakes are included as an indication of the relative status of lakes in the study area.

As pointed out earlier, chlorophyll a measures the amount of phytosynthetic green pigment in algae while water clarity, which is one of the most important parameters used in defining water quality, is determined by means of a Secchi disc. Personnel of the Biology Section noted that a near-hyperbolic relationship existed between chlorophyll a concentrations and Secchi disc readings. Figure 2 describes this relationship for 945 sets of data collected from approximately sixty lakes in the Province. Points for eutrophic or highly enriched lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration lie along the horizontal limb. Data for mesotrophic lakes would be dispersed about the middle section of the curve. Some caution should be exercised when comparing one lake with the next using our relationship as numbers of chlorophyll samples and Secchi disc readings varied from lake to lake. For example, only four sets of data were secured from Big Glamor Lake while eleven sets were acquired from Canning Lake; consequently, a more realistic appraisal can be obtained for Canning than for Big Glamor Lake. Chlorophyll a and Secchi disc data from Big Hawk, Boshkung, Shadow, Hall's, Stations A,B and C of Kenissis and Twelve Mile Lake were positioned in the oligotrophic portion of the curve; Big Glamor, Canning, Davis, Kashagawigamog, Moore's and Station COA of Kenissis Lake were in close proximity to Balsam and Cameron Lakes - two mesotrophic lakes of the Kawartha Trent River System. The enriched nature of Little Glamor Lake was evinced by its relation to Sturgeon, Pigeon and Chemung Lakes - three relatively productive lakes in the southern portion of the Trent Watershed. Significantly, all lakes in the study area were well-removed from the highly eutrophic waters of Riley Lake, Gravenhurst Bay, the Bay of Quinte and the Western Basin of Lake Erie.

As indicated in Figure 2, Stormy Lake was somewhat below the established relationship indicating that factors other than chlorophyll (i.e. colour, suspended material etc.,) governed light penetration in the lake. With specific reference to Little Glamor Lake, A Ministry of the Environment study (1971) indicated the extreme vulnerability of the lake,

"......to even small but continual inputs of phosphorus." The report pointed out that re-cycling of phosphorus from the bottom sediments to the overlying well-illuminated waters could eventually undermine the quality of water in the lake. The chlorophyll-Secchi data collected during the summer of 1972 re-confirms the critical nature of Little Glamor Lake.

Information collected in 1971 from both Big and Little Glamor Lakes (the only lakes having two consecutive years of data) indicates that higher algal densities and poorer water clarity conditions prevailed in 1972 than in 1971. Such year to year variations in water clarity and algal conditions - if continued on a long-term basis - will be extremely useful in assessing whether changes in water quality are materializing so that remedial measures can be implemented before conditions become critical. In light of the aforementioned, cottagers should consider a continuation of the Secchi disc - chlorophyll sampling programme.

APPENDIX A

WATER QUALITY IN RECREATIONAL LAKES

Bacteriological Water Quality

For many years, cottagers have generally equated water quality with the presence or absence of coliform or fecal coliform bacteria in the water. Certainly, localized bacteriological problems in recreational lakes associated with inadequate or malfunctioning cottage waste treatment systems are still all too frequent.

In June 1970, the Ontario Water Resources Commission (now within the Ministry of the Environment) implemented changes in the criteria for bacteriological quality of water. Under these criteria, water used for total body contact recreational activities is impaired when the coliform, fecal coliform and/or enterococcus geometric mean densities exceed 1,000,100 and/or 20 per 100 ml, respectively, in a series of at least ten samples per month, including samples collected during weekend periods (OWRC 1970).

Separate criteria are in force for private water supplies for individual dwellings and cottages. The raw water must be of such quality that it can be used with a minimum of treatment, limited to disinfection, filtration and/or softening. Microbiological criteria for private water supplies is provided in Table 1, of the Appendix.

Although bacteriological contamination is undoubtedly of most direct significance to cottagers, this type of pollution can be readily identified and through the implementation of effective controls, a rapid return to satisfactory water quality can be achieved.

Eutrophication

It is only within recent years that the more lasting effects of a type of pollution best described as nutrient enrichment have become clearly recognized. This process, scientifically known as EUTROPHICATION, is associated with sedimentation and increases in the dissolved mineral

content of a lake - specifically substances such as phosphates, nitrates, carbonates and numerous trace elements - increases which occur as a result of rainfall, land runoff and percolation of soil-water to the lake. Higher concentrations of these dissolved materials cause the water to become progressively more fertile and productive, stimulating the development of free-floating microscopic plants called phytoplankton - generally referred to as algae.

Algae are normal inhabitants of virtually all surface waters and fulfill an essential role in maintaining a balanced condition in the aquatic environment. They not only provide the entire nutritional base for a complex aquatic food web which includes the production of game and commercial fish species, but produce and release oxygen to the water which is vital to the metabolism of fish and all other forms of aquatic life.

The natural development of algae is regulated not only by nutritional factors, as previously mentioned, but by environmental factors such as temperature, the intensity and duration of illumination (sunlight) and by physical factors such as size, depth and shape of the lake bottom. Thus, the corresponding rates of eutrophication in different lakes are determined by varying combinations of extrinsic and intrinsic features.

All lakes, even the largest and deepest, are transitory bodies of water and are continually undergoing a gradual process of change from youth to maturity to old age, or in limnological terms, from oligotrophy to mesotrophy to eutrophy. Progressing even further, death of a lake can be equated to the onset of a "swamp" or "marsh" condition. In small, shallow lakes, this entire process may have occurred in some cases within a single century following the glacial retreat; in other instances, the process is well advanced, and still going on, and in many larger, deeper lakes remote from human influences, significant changes can only be measured on a geologic time scale (i.e. thousands of millions of years).

<u>Major differences in Ontario Lakes</u>

Lakes surrounded by granitic bedrock and the sparse infertile soils of the Precambrian Shield which covers Muskoka, Haliburton and areas further north are characterized by low rates of algal production and consequently age less than lakes surrounded by the deeper, richer soils of

Table 1: Microbiological criteria for private water supplies.

Micro-organisms		Permissible Criteria: Chlorination only	Permissible Criteria: Chlorination and Filtration	Desirable Criteria: No Treatment
Coliforms	(35 C)	100/100 ml	400/100 ml	0/100 ml
Fecal Coliforms	(44.5 C)	10/100 ml	40/100 ml	0/100 ml
Enterococci	(35 C)	1/100 ml	4/100 ml	0/100 ml
Total Bacteria	(20 C)	1,000/100 ml	4,000/100 ml	10/100 ml
Clostridia (in water)	(35 C)	0/100 ml	4/100 ml	0/100 ml

Raw water samples should be collected at least monthly. The Geometric Mean of sample results should not exceed the values given in the table above.

Southern Ontario. Correspondingly, "nutrient-poor" lakes on the "Shield" having moderate to extreme depths, generally support a relatively low production of cold-water species such as lake trout, whitefish and herring. Such lakes are characteristically clear and well-suited to swimming and other water-oriented recreational pursuits. Also the deeper waters are well-supplied with oxygen throughout the year. This latter condition relates to the low algal production and concomitant lack of any significant oxygen depletion associated with the decomposition of algae at the lake bottom.

Alternatively, fertile lakes, such as the Kawarthas, are more turbid owing to the increased phytoplankton production and presence of suspended particulate matter. They contain substantial growth beds of submergent leafy vegetation such as water milfoil, elodea, coontail and pondweeds and produce higher yields of warm-water species such as walleye and bass.

Adequate levels of dissolved oxygen are generally present from surface to bottom since these lakes are shallow and benefit from the high level of phytosynthetic activity, as well as surface aeration and complete vertical mixing during periods of windy weather. The Kawartha Lakes have been extremely productive for many years and can be considered as naturally eutrophic waters.

The overriding factor of artificial fertilization has created different types of problems in these two major types of lakes. Enrichment studies have been carried out by personnel of the Ministry of the Environment at the request of concerned cottagers on lakes in northern and central Ontario such as Little Panache (near Sudbury), Riley Lake (near Gravenhurst), Silver Lake (near Port Carling), Big Straggle Lake (near Bancroft) and several others which can be considered representative of most lakes on the Shield. To varying degrees, these investigations revealed the classical evidence and undesirable features of induced fertilization in these thermally stratified lakes. Affected lakes are characterized by increased phytoplankton levels, the development of high numbers of blue-green algae in late summer and reduced pH and dissolved oxygen concentrations in the deeper waters associated with the decomposition of settled algae and higher carbon dioxide, nutrient and iron levels, again particularly evident in the deeper water where reducing conditions prevail.

Associated undesirable effects of induced eutrophication in one or more of these situations were a reduction in water clarity and related impairment of the recreational and aesthetic qualities of the water, objectionable accumulations of blue-green algae along shorelines and associated malodourous conditions on decomposition, a decrease in the quality of the water for drinking and domestic purposes including clogging of water intake filters, a reduction of the area suitable for game fish owing to oxygen reduction in the deeper waters and a further reduction in fish production through elimination of desirable fish-food organisms.

In lakes like the Kawarthas, on the other hand, increased enrichment resulting from agricultural runoff, urbanization along the system and inadequate containment of cottage wastes has placed increasing stress on an already productive aquatic environment. Here, artificial nutrient inputs have intensified the production and frequency of blooms of blue-green algae and have enhanced the production of aquatic plants to the point where many activities such as swimming, water skiing and unimpeded boating are practically impossible. Prolonged periods of hot, calm weather have periodically caused decomposition of algae and aquatic plants in isolated bays where limited water exchange has resulted in dissolved oxygen depletion and accompanying fish mortalities. Also, periodic winter kills of fish resulting from organic decomposition have been a recurring problem. It is certain that heavy densities of weeds in many areas interfere with the harvest of game fish and it is a moot point whether or not existing conditions actually favour or interfere with optimum game fish production.

How the cottagers can help

In a direct way, each cottager can do his part by ensuring that his waste treatment system conforms to present standards and is operating efficiently. Neighbouring cottagers should be encouraged to do likewise and situations such as effluent ponding or surfacing, which will obviously contribute to water pollution, should be brought to the immediate attention of local public health authorities. The use of phosphate-free washing compounds is highly recommended. In past years approximately 50% of the phosphorus contributed by human sewage was added by detergents. On August 1, 1970, federal regulations reduced the phosphate content as P_2O_5 in laundry

detergents from approximately 50% to 20%. Additional regulations which were effected on January 1, 1973, further decreased the phosphate content to 5%. Cottagers having any doubt about the possibility of nutrients reaching the lake from their treatment systems should refrain from installing automatic dishwashers which require high phosphate cleansing products (a 1970 questionnaire indicated that about 30% of the cottages in the Muskoka Lakes have automatic dishwashers). Such conveniences may contribute significant amounts of phosphorus to recreational lakes. Indeed, in most of Ontario's vacation land, lake water used by cottagers is sufficiently soft to allow for the exclusive use of soaps and soap flakes.

A significant number of cottage owners apply lawn and garden fertilizers each year to promote vigorous growth. Use of fertilizers should be restricted as much as possible and should be discontinued if translocation to the lake is deemed likely.

Unless cottagers endeavour to understand the causes and consequences of artificial nutrient enrichment and eliminate offending practices and inadequate treatment systems, water quality is certain to be undermined for future generations.

GLOSSARY OF TERMS

ALGAE - An assemblage of simple, mostly microscopic non-vascular plants containing photosynthetic pigments such as chlorophyll. Algae occur suspended in water (phytoplankton) and attached to rock and other suitable substrates. Some algae may produce nuisance conditions when environmental parameters are suitable for prolific growth.

CHLOROPHYLL - The photosynthetic green pigment which occurs in all algal divisions.

EUPHOTIC ZONE - The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.

EUTROPHIC - Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION - The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the production of dense nuisance growths of algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.

MESOTROPHIC - Water characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).

OLIGOTROPHIC - Waters containing a small nutrient supply and consequently characterized by low rates of organic production.

SECCHI DISC - A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants and so painted that two quadrants directly opposite each other are painted black and the intervening ones white. The Secchi disc is used to estimate the depth of the euphotic zone.